SOCIAL COMPLEXITY
IN
PREHISTORIC EURASIA

MONUMENTS, METALS, AND MOBILITY

EDITED BY

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2009

CAMBRIDGE
UNIVERSITY PRESS

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CHAPTER 11

Production and Social Complexity

Bronze Age Metalworking in the Middle Volga

David L. Peterson

Researchers consider metal production to have been second only to pastoralism as a form of productive economic activity in the Middle Volga region throughout the Bronze Age (Vasil'ev et al. 2000: 8). This presents an interesting paradox. There is virtually universal acceptance of the high social significance of early metal making in the steppes, as shown particularly by the integral role of metal artifacts in kurgan burial rites. However, metal appears to have been produced on a relatively small scale in many areas, including the Middle Volga, for much if not all of the Bronze Age. Although many archaeologists have assumed that metal was important in the past because of its "self-evident usefulness or inherent attractiveness" (Sherratt 1997: 103), its value was foremost a product of human knowledge, labor, and interactions, in which even very small-scale production could have been of considerable local importance. The association of metalwork with kurgan burial rites indicates that metal was not perhaps necessary for survival but may have been a social necessity, at least for a certain level of social identity that could be negotiated or maintained in interactions surrounding the production and acquisition of metalwork. What is less clear is how participation in metal making, as opposed to maximization of output or control of product, contributed to the emergence of social complexity in the Middle Volga or elsewhere.

The metal-making process involved a temporally extended sequence of activities that were often carried out by different hands in different places (Fig. 11.1). The efforts of a number of producers (miners, smelters, metalworkers, those who raised the food they ate, etc.) contributed

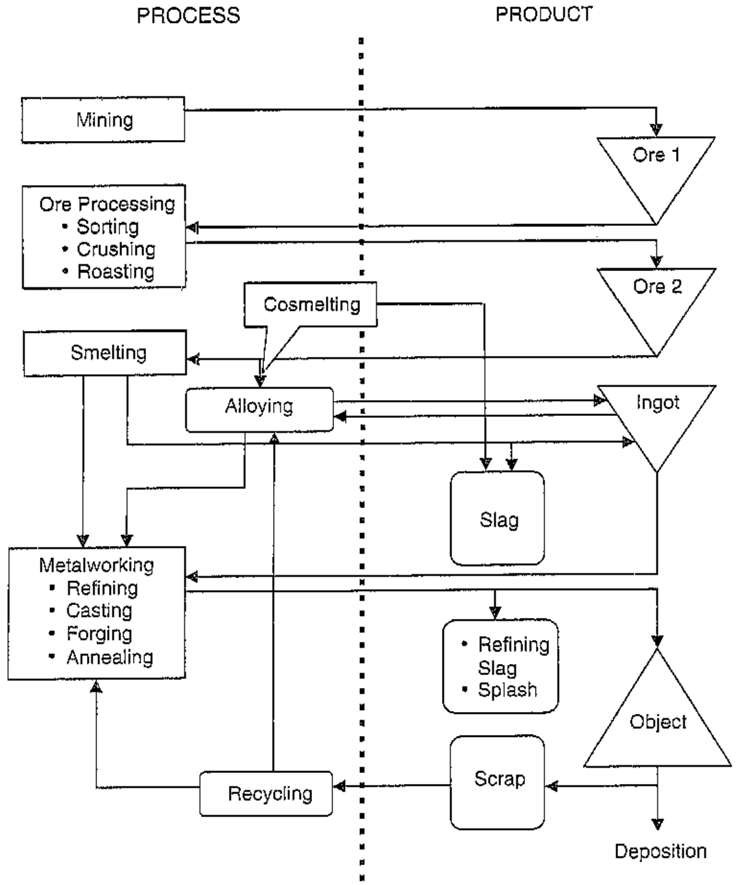

Figure 11.1. The overall metal-making process for ancient copper and bronze, including activities and products associated with recycling.

to the production of copper and bronze metalwork in Eurasia during the Bronze Age. Such geographic divisions of labor are what distinguish "metallurgical focuses" from "metalworking focuses" in E. N. Chernykh's (1992) metallurgical province system. If we judge from the small scale of metal production known from the Middle Volga before the specialized production known at Mikhailo-Ovsyanka during the Late Bronze Age (LBA) II period (Matveeva et al. 2004; Fig. 11.2), the efforts of producers, and the interactions that brought them together in the fabrication of finished objects, were more critical to the creation of metalwork than

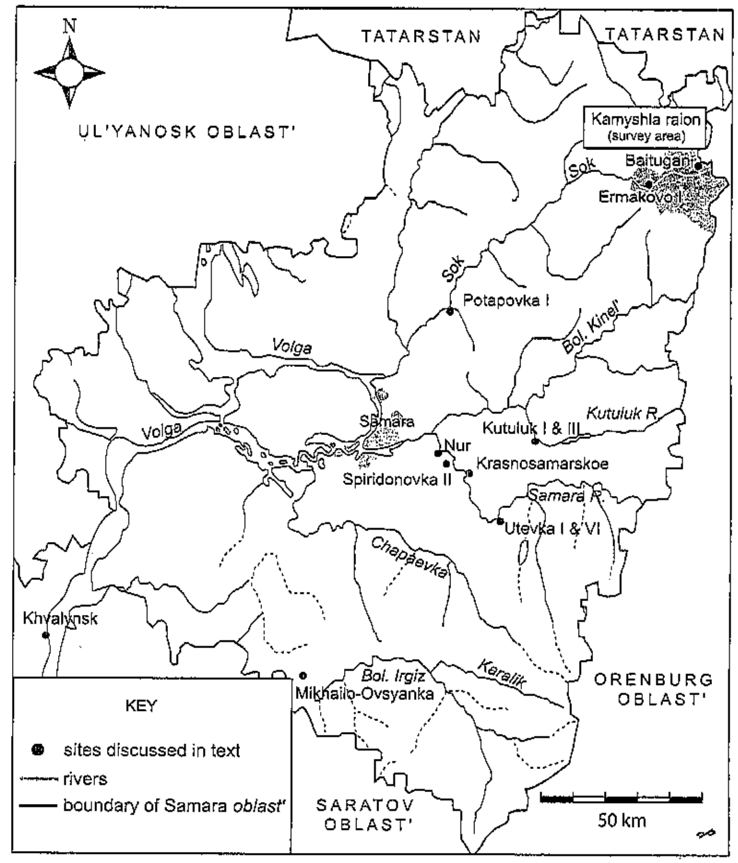

Figure 11.2. Map of Samara Oblast' showing sites and localities discussed in the text (drawing by David Peterson).

limits of supply alone. This does not mean that metalwork should be approached as simply the outcome of the time and energy that went into making it. In most cases, the knowledge, skills, and experience needed for metalworking could be transmitted and acquired only through the participatory learning that occurs in apprenticeship (Keller and Keller 1996). Therefore, the labor power associated with metal making could have been easily controlled through social restrictions on the transmission of skills and knowledge and on who could be a producer. Social distance and distinctions could also be created in the metal-making process itself, if divisions of labor and specializations arose in which some parties were forced into more onerous or hazardous occupations, like mining,

Period	Years BCE	Horizon Style
LBA II	1500-1300	Late Srubnaya
LBA I	1800-1500	Early Srubnaya
MBA II	2200-1800	Potapovka
MBA I	2800-2200	Poltavka
EBA	3300-2800	Yamnaya

Figure 11.3. Chronology of the periods in Middle Volga prehistory and archaeological style horizons that are discussed in the article.

while others were better rewarded for their efforts (cf. Shennan 1999a). Under these circumstances, it is likely that expansion in the scale of production and exchange of metal by one group would have been viewed as a threat to the status quo by many of their existing partners.

In this chapter, I examine some important aspects of the relationship between the production of metalwork and the emergence of social complexity in the Eurasian steppe, utilizing results of my recent investigation of Bronze Age metal making in the Samara Oblast', in the Middle Volga region of present-day Russia (Fig. 11.2). I examined metalwork from contexts relating to several Early to Late Bronze Age horizon styles in Samara (Fig. 11.3). Here I pay special attention to objects from the Potapovka I and Utevka VI kurgan cemeteries (Fig. 11.2). These are the principal sites of the Potapovka horizon, which has close affinities to sites of the contemporary Sintashta-Arkaim horizon further east. The latter are associated with the early complex societies of the southern Urals region that are the topic of several contributions to this volume.

The examination of metalwork from Samara, including pieces containing arsenical bronze that originated from the southern Urals, provides important details on the inter-regional relations that surrounded metalwork in the Volga-Ural in the late third to early second millennium BCE. Despite the intensification in metal production by at least some communities in the Urals at that time, the Middle Bronze Age (MBA) II inhabitants of the Samara area did not simply acquire the metalwork they placed in kurgan burials by exchange with more "metal-rich" communities to the east. There is good reason to believe that local

artisans in the Middle Volga region of the Volga-Ural steppe and forest-steppe practiced recycling and maintained their own metal pools even within different areas of the Middle Volga. It was not simply the local ownership of metalwork but also the performance of metalworking in the creation of finished pieces that was key to providing the copper and bronze objects placed in kurgan burials.

It is possible that at least some of the increased output from the Urals was destined for exchange with new partners in Central Asia. What is just as significant, or maybe more so, is the evidence that copper began to be cast in consolidated ingots at this time (Zaikov and Zdanovich 2000: 83, figs. 4.6, 85), an indication that the commoditization of metal itself was underway. In this way, an old form of mystification may have been traded for a new one, as authority vested in socially restricted practices may have begun to be superseded by production for exchange, and the closer association of the value of metal products with the material itself. Processes like this, which entail the emergence of new regimes of value, are not merely economic but are inevitably political as well (Appadurai 1986). Such developments may have been viewed by other partners in Samara and neighboring regions as a threat to older systems of status and authority that incorporated metal making. This might help to explain why the shift that occurred in the production and consumption of metal in Eurasia at this time appears to have contributed to growth in militancy and conflict in the steppes by the late third millennium BCE. This includes the implications of the mass grave at Pepkino (Chernykh 1992: 201; Koryakova and Epimakhov 2007: 62–63, 66), as argued by Anthony in this volume, as well as the emphasis on weaponry that is a hallmark of metalwork from Potapovka I and Utevka VI (Agapov and Kuz'minykh 1994; Kuznetsov and Semenova 2000; Vasil'ev et al. 1992, 1994).

Metal and Authority

An examination of the cross-cultural significance of metal making suggests the kind of significant relationship between metal and political ritual authority that may have also existed in the Bronze Age, and what may have been at stake in the shift in production and consumption that was underway in the MBA II period in the Volga-Ural. Myths and religious texts indicate the strong associations that people in the past drew between metal and divinity, temporal authority, and moral imperatives, in which the significance of metal and metalwork extended well beyond their sheer economic importance. For example, in the Scythian creation story reported by Herodotus, the Scythian *ethnea* came into being as the first king, Kolaxais, seized four golden objects that had been fashioned by the gods as they came down from the sky (*Histories* 4.5–7). Thereafter, the lives of the Scythian kings are said to have depended on proper treatment of the sacred gold, which they were obligated to display and renew annually with public sacrifice and feasting lest they meet with an untimely death in the year that followed (Lincoln 1991: 192).

This legend encompasses a number of associations that ethnographers and historians commonly link with metal making. One is the spirit that is frequently associated with an object's donor(s) (Mauss 1990). Another attributes metal with a supernatural origin or traffic with outside forces, either divine or sinister, including the positive or negative status traditionally given to metal producers. Although these elements often lack clear material correlates, Budd and Taylor (1995) and Haaland (2004) also blame unproductive modern biases for the frequent hesitance to consider these aspects in archaeological accounts of ancient metalwork. Ethnographic and historical accounts of the ritual, symbolic, and transformative significance of metal, metalworking, and its products have a role to play in improving the present understanding of the relationship between metal production and early social complexity in the Eurasian steppe, particularly at the level of explanation and interpretation.

A common feature in such accounts is the animistic association of metal production with gestation, in which metal producers are often attributed with the power to unnaturally accelerate this process in earthly matter (Eliade 1978; Childs 1991: 40). One of the most important figures in the history and anthropology of Eurasia is the shaman, whose drum and the forge are sometimes metaphorically interchangeable. The trance sought through drumming might also be achieved in the hammering associated with metalworking. Shamans are commonly associated with mastery of fire, including direct or symbolic participation in working iron (a material credited with the potential to control hostile spirits), including the creation of a "body of iron" that made the shaman resistant to hostile spiritual forces (Eliade 2004). This is a particularly literal example of the anthropomorphic analogies that frequently crop up in relation to smelting and metalworking, in which metal making may be viewed at the same time as the perfection of the self. This further indicates the attraction of controlling the circulation of even a small level of output, and the potential that participation in production often held for legitimizing authority.

This may be true of earlier periods as well. As Budd and Taylor (1995: 139) have stated, the shamanic charisma of the metalworker may have coincided with public authority in Bronze Age Europe, as "the ability to put on a show of colorful, transmogrifying pyrotechnics may have commanded considerable respect." Copper-based figurines from Galich and elsewhere in the pre-Urals region (Chernykh 1970: fig. 63.17–18; 1992: pl. 20) may be evidence of similar associations between metal making and political authority in Bronze Age Eurasia. These anthropomorphic statuettes have what appear to be axe blades and tanged knives sprouting from the head and shoulders, suggesting the incarnation of forces associated with metal in human form. Alternatively, they may depict a divinity or culture hero as the giver of bronze tools and weapons, which are represented as emerging from the very body of the figure itself.

There is no way to definitively prove that these understandings were at play in the Bronze Age steppes, but they are suggested by the tantalizing glimpses that archaeological remains provide of the ceremonial importance of metal and metalworking tools, such as founder's burials in which casting molds and other tools were placed in the grave (e.g., the collective grave at Pepkino, Chernykh 1992: 201; Koryakova and Epimakhov 2007: 62–63, figs. 1.2 and 2.10). In this way, the apparent relationship between metalwork and social identity may have extended to metal *working* and social identity as well (Peterson 2007: chap. 3). In kurgan burial ceremonies, not only metal objects but also molds and other pieces that objectified the power associated with the fabrication of metalwork may have served as an index of the social prominence of the deceased and their survivors. The social significance of metal may have been situated not only in metalwork as a "fetishized commodity" (McLellan 2000: 435–443) but, like shamanism, also in the knowledge and practice of the activity itself.

Metalworking

The results of the archaeometallurgical analysis of Bronze Age metalwork from Samara that are summarized in this chapter allow me to provide some sense of the complex political economy that surrounded metal making in the Middle Volga and its relationship to broader developments in the Volga-Ural (Peterson 2007). In drawing associations between metal and early social complexity, researchers frequently emphasize large-scale mining, the generation of surpluses, long-distance exchange, and the accumulation of wealth in burials. However, just as the activities that were part of Eurasian pastoralism were not uniform across space and time, and a certain level of complexity was not a blanket condition at any given (pre)historical moment (see respective contributions by Popova and Frachetti in chapters 16 and 3 in this volume), the practices involved in metal production were also subject to change and a wide degree of variation.

Identifying the metal-making activities that were carried out in a site or region during a particular period is important to understanding the relationship between metal and social complexity in that instance. Without such an understanding, there is a risk of evaluating every case in terms of a standard of large-scale, industrial production. While there is evidence in some cases for production on a substantial scale (e.g., Chernykh 2002), in others it may be less representative of how early metal production was carried out than of our own historical experience and anachronistic ideas of how production should have operated (Budd and Taylor 1995).

In general, metalworking is examined far less often than other aspects of metal production, even though it provides an essential link between mining and smelting, on the one hand, and the consumption of finished metal objects, on the other, in the overall metal-making process. Metalworking was a key activity in the earliest exploitation of gold and native copper (Muhly 1980; Renfrew 1986) and remained the dominant form of metal production in some regions during not only the Late Eneolithic but also the Bronze Age (Taylor 1999). There is a variety of evidence such as metal scrap and small, unconsolidated ingots, as well as data from metallography and EPMA-WDS analysis, that indicates that metalworking was practiced locally within Samara during the Bronze Age and involved the maintenance of local metal pools and frequent recycling (Peterson 2007: chap. 7).[1] Although discussions of ancient Eurasian metalwork have frequently assumed a direct correlation between the element composition of the metal in objects and their sources, practices such as alloying and recycling can alter the element profiles of copper and bronze to the point that the origin of the materials found in individual pieces is hopelessly obscured. Recycling also has significant socio-economic implications, as it changes the production cycle from one that is initiated with mining to another in which metalworkers may operate more independently from miners and smelters (Fig. 11.1). A detailed understanding of the metalworking practices that occurred after the "primary" production of metal from ore is therefore crucial to addressing basic questions concerning the origin of materials and objects, as well as the socio-cultural significance of metalwork to the Bronze Age inhabitants of the steppes. This significance included the impact of broad shifts in production and consumption, and the divisions of labor and society that accompanied emerging social complexity.

Bronze Age Metalworking in the Middle Volga

Most of the Middle Volga region is encompassed by the Samara Oblast', covering an area of 53,600 square kilometers at the Volga "bow" (Russ. *luk*) and its confluence with the Samara River, which begins as an offshoot of Ural River to the east (Fig. 11.2). The Samara Valley links the Middle Volga to extensive ore deposits in the Urals, which provided copper for metalwork in the western steppes by the third millennium BCE, as, for example, in the early utilization of Kargaly (Chernykh 2002). The Volga also connects the Samara area, by way of the Caspian Sea and its western shoreline, to sources of copper and arsenic bronze in the Caucasus. Arsenic bronze appeared in steppe metal assemblages by the Middle Bronze Age. The foundation of the city of Samara dates to 1586, when the Samarsky fortress was built at a strategic point in relations with steppe nomads to the southeast (Pavlov 1996: 11, 15). Perhaps it is its strategic position at the crossroads of Europe and Asia, and the southern steppes and boreal forests, that made the Volga-Ural so important in the earlier development of expansive prehistoric networks, especially those which appeared in the Late Bronze Age in association with the Srubnaya horizon style (Bochkarev 1991). Previously, 70–80% of some 300 Bronze Age metal artifacts that had been recovered in Samara had never been analyzed. Altogether, these factors have made Samara a promising setting for a long-term social history of early metalwork in Eurasia.

The present research has had two main components (Peterson et al. 2006; Peterson 2007: chaps. 6 and 7). The first is an archaeological survey performed in the Kamyshla *raion* of northeastern Samara, with the goal of investigating the contribution of local copper production to the consumption of copper-based metalwork during the Bronze Age.[2] The second is the archaeometallurgical analysis of the materials, techniques, and properties associated with samples of Bronze Age metalwork examined from Samara.[3] This analysis centered on element composition, utilizing electron probe microanalysis with wavelength-dispersed spectrometry (EPMA-WDS, or simply WDS); Vickers hardness testing, for comparison of the relative hardness of different materials as they were worked in different objects; and metallography, for the micro-structural examination of the metalworking techniques that were used by the smiths who made the objects (Goldstein et al. 2003; Northover 1998, 2002; Scott 1991). Techniques are an important area of research in the anthropology of technology for which there may be little or no site-based evidence, but they can still be addressed in metal artifacts through a program of analysis that includes metallography. The combination of these methods allowed for a more detailed characterization of the fabrication of ancient copper-based metalwork than would have been possible by any individual mode of analysis alone (Northover 1985, 1989).

The objectives of the WDS analysis were to determine the material selected for each object and class of object, to ascertain how these preferences changed with time, and to attempt to identify sources of materials by patterns in the impurities present in the metal. These patterns did not show the 1:1 correspondence between objects and individual sources of ore. Instead, they provided important evidence of the maintenance of metal pools by different groups of smiths operating in the Middle Volga in the late third to early second millennium BCE.[4] In addition, relationships were sought between impurity patterns and periods, alloys, and object class. Metallography was used to examine other relationships between techniques of metalworking and material, object class, and context. It has often been assumed that bronze was utilized for its potential for greater hardness than unalloyed copper, but the properties achieved in individual instances depended upon how the object was worked. Malleability and toughness instead appear to have been among the most important properties that metalworkers exploited in early bronze in the Middle Volga (Peterson 2007: chap. 7).

Samples from 86 objects were examined from Samara.[5] Samples were taken from two different areas on two of the objects, bringing the total number of analyzed samples to 88. The forms included a variety of tools, weapons, fasteners, and ornaments (Fig. 11.4). The major metal groups identified by WDS were copper (45 samples), arsenic bronze (26 samples), and tin bronze (13 samples). One small ring was made of 99 wt% silver (Fig. 11.4: 11), and "spiral" pendants were covered over with a very thin foil of electrum (gold and silver), only 0.1 millimeter thick (e.g., Fig. 11.4: 16). For each sample, at least 5, and in many cases, 10 analyses were performed for 16 different elements: Fe, Co, Ni, Cu, Zn, As, Sb, Sn, Ag, Bi, Pb, Au, S, Al, Si, and Mn. The normalized results for each element were averaged for each object and form the basis of the present discussion of element composition.

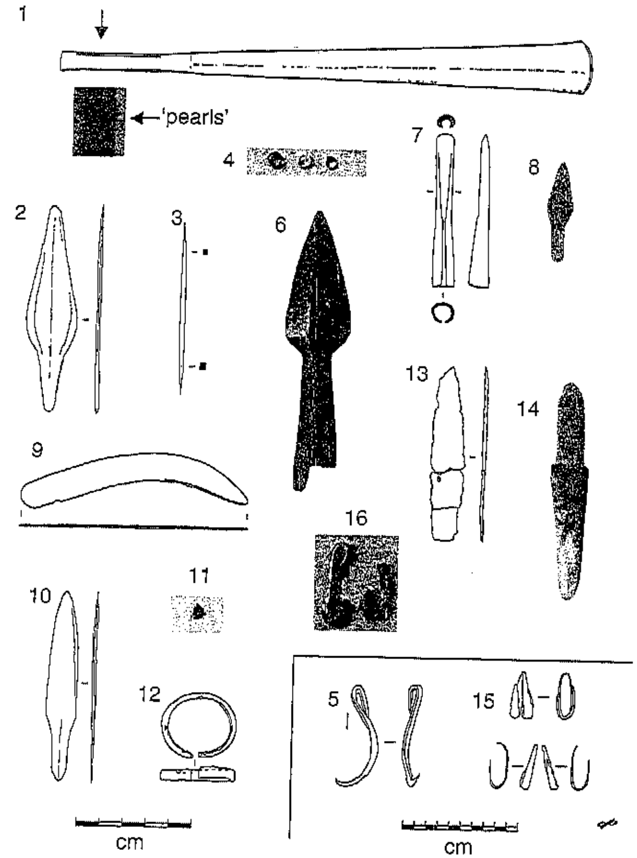

Figure 11.4. Examples of the metalwork examined in the study. *Yamnaya-Poltavka horizon:* (1) Kutuluk I, kurgan 4, grave 1; (2–3) Kutuluk III, k. 1, g. 2; (4) Nur, k. 2, g. 4; *Potapovka horizon:* (5) Utevka VI, k. 6, g. 2; (6) Utevka VI, k. 6, g. 4; (7) Utevka VI, k. 6, g. 6; (8) Potpovka I, k. 3, g. 5; (9) Utevka VI, k. 6, g. 6; (10) Utevka VI, k. 6, g. 1; (11) Potapovka I, k. 3, g. 5; (12) Utevka VI, k. 6, g. 11; (13–14) Grachevka II, k. 8, g. 8; *Srubnaya horizon:* (15) Spiridonovka II, k. 6, g. 35; (16) Nizhnyaya Orlyanka, k. 3, g. 8 (1–3, 14: copper; 4–10: arsenical bronze; 11: silver; 12–13, 15: tin bronze; 16: electrum foil over copper/bronze) (drawings by David Peterson).

Out of the 86 objects examined, 5 were from the Early and Middle Bronze Age Yamnaya and Poltavka or Yamnaya-Poltavka horizons (Figs. 11.3 and 11.4: 1–4). During the Yamnaya and Poltavka periods (EBA and MBA I), metalworkers in the Middle Volga produced copper implements common to the Circumpontic region in the third millennium BCE (Chernykh 1992: 83–91, 132–133). These included tanged knives and daggers, tetrahedral awls and chisels, adzes, and occasionally shaft-hole axes (Fig. 11.4: 2–3). The social significance of these forms is indicated by their limited presence in burials and general absence from other contexts, which belie their deceptively utilitarian nature. An early example of an unusual object that appears to have had high social significance is a large copper staff from a kurgan burial at Kutuluk I (Figs. 11.2 and 11.4: 1), radiocarbon dated to circa 2930 BCE (Kuznetsov 1991). It was found cradled scepter-like in the left arm of the deceased, apparently as a symbol of status and/or authority (Kuznetzov 1991: 138). The staff has stylistic affinities with some shaft-hole axes in the form of a few worn-down, pearl-like beads in the grip area (Chernykh 1992: fig. 28.24). These are similar to the "pearls" on some Yamnaya ceramics in the Volga-Ural, skeuomorphs of the rivets in contemporary sheet-cauldrons in the northern Caucasus (Mochalov 2008), and daggers from the northern Black Sea region (Anthony 1996).

Following the conventional identification of an alloy by the presence of admixtures at levels of 1% or more by weight (wt%), the WDS values show the presence of 26 arsenic bronzes among the samples, with arsenic content as high as 14 wt%, but mostly centered on 1.5–2.5 wt% (Fig. 11.5). Three date to the MBA I (Poltavka) period and are from the Nur cemetery, kurgan 2, grave 4 (Figs. 11.2 and 11.4: 4). Nineteen are from Potapovka horizon burials (MBA II), in the form of tools, weapons, and ornaments, including the chisel and socketed spearhead from burials in kurgan 6 at Utevka VI (Figs. 11.2 and 11.4: 5–7, 9–10). In relation to the concentration of arsenic values at the lowest end of distribution, the numbers that cluster around 1.5–2.5 wt% at first seem as though they could possibly be part of the higher peak for values in a bimodal distribution, in which the higher peak would represent bronze, and the lower would correspond to the presence of arsenic as an impurity in the copper. However, the log-normal distribution curve for arsenic concentrations (Fig. 11.5) instead suggests that concentrations of arsenic in the overall metal pool were in the process of diminishing to practically nothing, as occurs when copper and bronze with higher and lower levels of arsenic are mixed together numerous times over an extended period (P. Northover personal communication). The way in which values above 1 wt% blend into the group below indicates the probability of frequent recycling.[6]

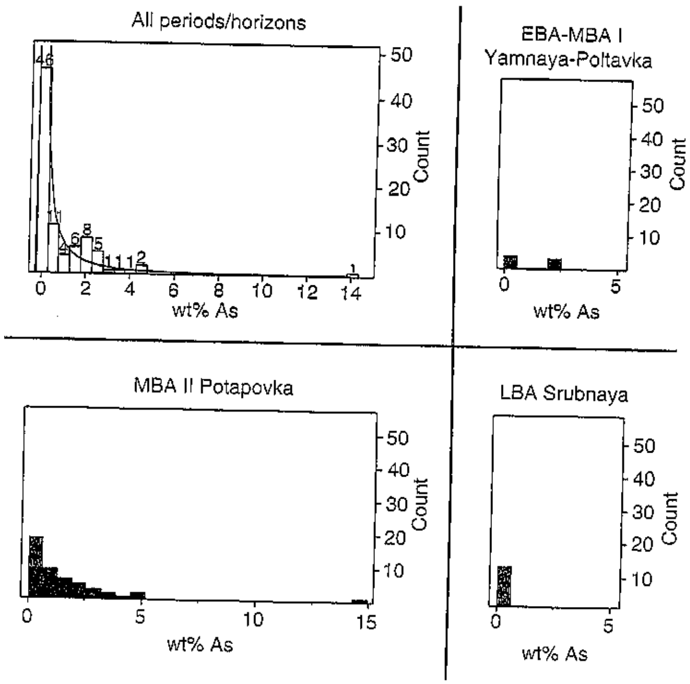

Figure 11.5. Arsenic concentrations in the Bronze Age metalwork from Samara based on WDS results. The log-normal curve for all is superimposed at top left.

There are fewer tin bronzes among the samples, 17 in all. One of the main reasons is that the majority of the objects examined (N = 62) belong to the MBA II Potapovka horizon, and tin bronze is more strongly associated with the Late Bronze Age. Most of the tin bronzes are Srubnaya ornaments (e.g., Fig. 11.4: 15). The exceptions are a knife from Grachevka II, kurgan 8, grave 8 (Fig. 11.4: 13), and five bracelets from other Potapovka horizon graves (e.g., Fig. 11.4: 12). Unlike the WDS results for arsenic, in those for tin there is a sharp cutoff between the levels that indicate alloying and those associated with the presence of tin as an impurity. The tin bronzes in this case start around 3 wt%, while the highest tin value below that is only .08 wt% (Fig. 11.6a). The wide spread of alloy-level values for tin may be a further indication of recycling practices, but in which tin bronze was recycled less frequently than arsenic bronze, and in which the two alloys were kept separate.

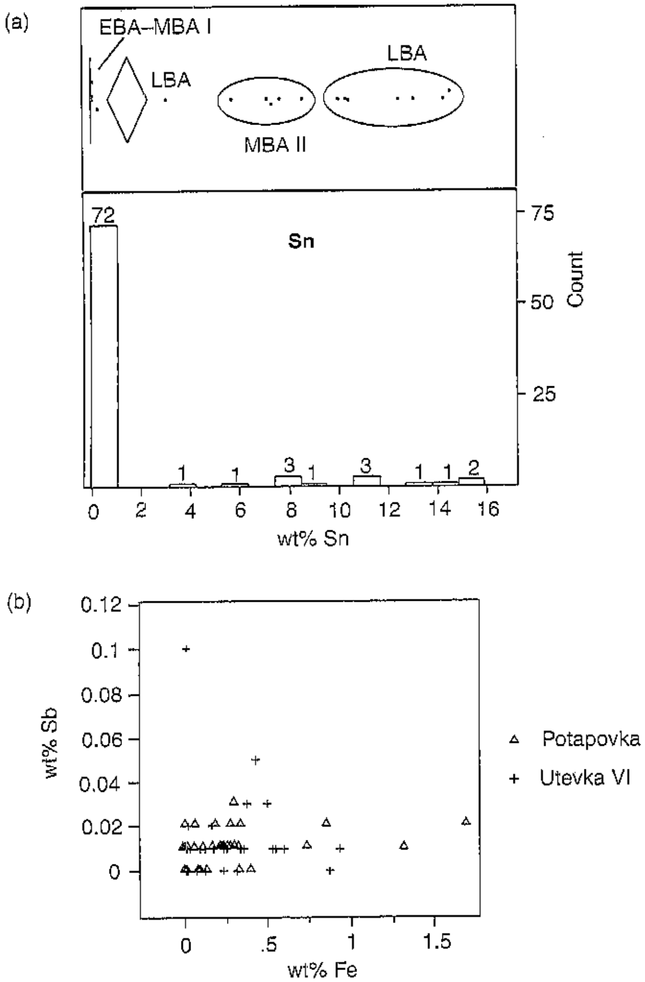

Figure 11.6. (a) Tin concentrations in the Bronze Age metalwork from Samara based on WDS results. As noted, the highest values are for MBA II and LBA, the lowest for EBA–MBA I. (b) Potapovka horizon: scatterplot of values for concentrations of antimony (Sb) v. iron (Fe), from WDS results for metalwork from Potapovka I and Utevka VI.

This prevented the formation of tin-arsenic bronze as each was apparently mixed with unalloyed copper but not with one another.[7]

A multivariate analysis of the 15 elements measured besides copper showed the strongest correlation between nickel and arsenic (.55; or a little more than 50%). Within the scatterplot of values for nickel

and arsenic are groupings related to both period and cultural affiliation (Peterson 2007: fig. 7.81). These suggest that the metalworkers who forged the pieces analyzed from the Potapovka horizon drew on a greater number of sources than those who came before and after them.[8] In light of the increase in metal production that began in the southern Urals around the turn of the second millennium BCE, it is quite likely that this pattern is in part the result of the circulation of copper from a greater number of sources in the MBA II period than previously in the Middle Volga.

When values for iron are plotted against those for antimony in the WDS results for samples from Potapovka I and Utevka VI, it appears that the smiths who made these two groups of objects may have drawn from different, overlapping metal pools (Fig. 11.6b).[9] The Potapovka I group tends toward higher iron and lower antimony, whereas that for Utevka VI tends toward higher antimony and lower iron. One way to explain these differences is to attribute the objects in each cemetery to different groups of metalworkers, who maintained their own networks for the acquisition of materials and engaged in slightly different practices in fabricating the pieces. These metalworkers may have lived and worked within separate pastoralist communities centered on the Sok and Samara river systems on which the cemeteries are respectively located (Fig. 11.2).

The metallographic analysis yielded equally intriguing results. The samples were examined at 75x to 750x magnification. The micrographs (Peterson 2007) are summarized here in terms of work pattern in Figure 11.7. In the 81 samples from Samara for which work pattern (WP) was identified, four basic patterns were encountered: WP 1, cast and only lightly cold-worked objects (rare – in only 1 sample or ~1% of the total); WP 2, objects that were cast and then annealed, restoring the malleability of the cold-worked metal, followed by additional cold work (42 samples or ~52%); WP 3, objects that went through all the preceding steps but were also heavily cold worked to the point of heavy cold-work reduction, creating a "flattened" or "feathered" appearance in the crystal grains (34 samples or ~41%); and WP 4, objects with a micro-structure of relatively small crystals overall (Fig. 11.7). The last was probably a result of many bouts of alternating cold work and annealing (infrequent – 4 samples or ~5%).

The one sample that was made utilizing WP 1 is the knife from kurgan 8, grave 8 in the Grachevka II cemetery, which is assigned to MBA II or the transition from MBA II to LBA I (Figs. 11.4: 13 and 11.7: 1).

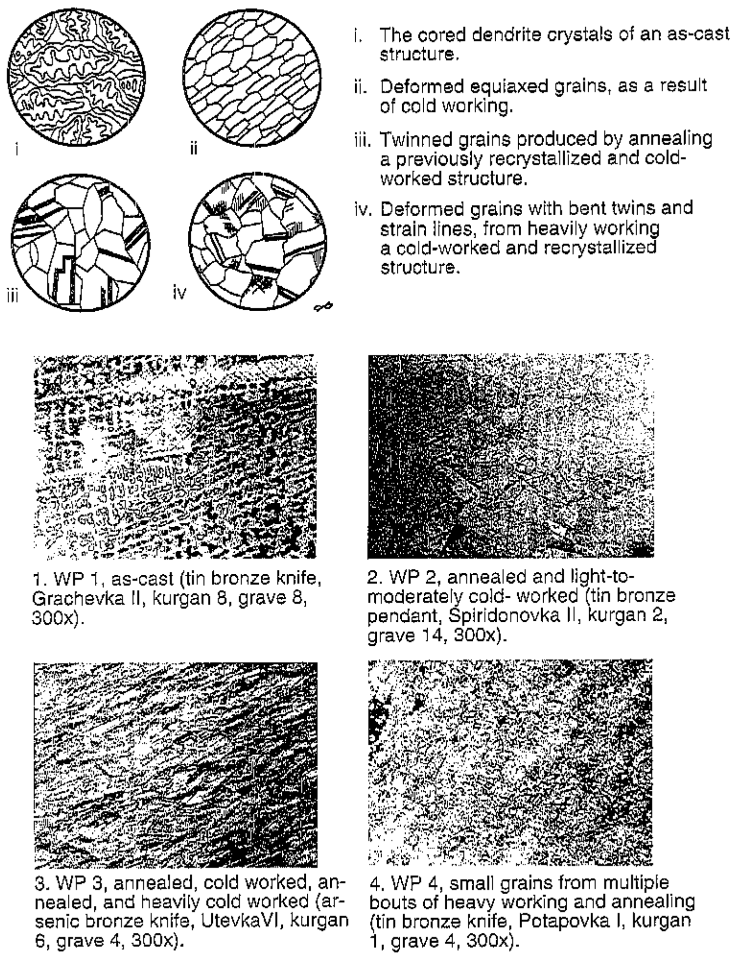

Figure 11.7. Work patterns (WPs) identified in the Bronze Age metalwork from Samara. Drawings are representations of some of the important microstructures associated with the work patterns (drawings by David Peterson after Scott 1991: fig. 12).

The object is a medium tin bronze (Sn 5.7 wt%) that is heavily corroded. The form is unusual, apparently a one-sided blade with a straight or slightly curved back, and is found in the Sintashta-Arkaim horizon (Gening et al. 1992: fig. 153.20) but is more typical of the East Urals in the Late Bronze Age (Chernykh 1992: fig. 82.14, 16). Although the sample from this knife was the only one showing the dendritic structure

of unworked (or very lightly worked) metal, which had also not been annealed, there were 21 (~26% of samples) with the residual coring (or "ghosts") associated with partial retention of the "as-cast" structure.[10] These samples may provide clues to differences in the control of annealing temperatures with copper and bronze. Twelve samples, or more than half the total with residual coring, are of unalloyed copper, while, of the rest, 6 are arsenic bronze and 2 are tin bronze (Peterson 2007: table 7.5). This presents an interesting pattern, because out of a combined total of 45 objects of arsenic and tin bronze, only 8 were found to have residual coring (~18%), as compared to a total of 12 out of 44 for unalloyed copper (~27%). It suggests that the metalworkers who made the objects may have taken greater care in annealing bronze than copper, even though the former requires a temperature of 2 to 2.5 times greater than that needed to re-crystallize the latter.[11]

The number of samples that date earlier than MBA II is small; therefore, observations for them do not carry the same weight as those for the Potapovka horizon materials. Of the Yamnaya and Poltavka metalwork examined metallographically, two are of unalloyed copper fabricated by WP 2 (Fig. 11.4: 1–2). The other three are the arsenic bronze rings from the Nur cemetery (Fig. 11.4.4), relatively rare examples of Poltavka ornaments and early low-arsenic bronzes (~2 wt% As). Two of the rings from Nur were worked with WP 2, the third with WP 3. The Potapovka horizon objects include a large majority of the metalwork from the Potapovka I and Utevka VI cemeteries, the two most heavily investigated sites of the Potapovka horizon (Kuznetsov and Semenova 2000; Vasil'ev et al. 1992, 1994). Out of a combined total of 60 samples examined from both cemeteries, the frequency of WP 2 and WP 3 is quite close, with 27 samples showing WP 2 (46%), as compared to 29 with WP 3 (49%). Only 4 represent WP 4 (5%).

It is more informative to compare the results for samples from the Potapovka I and Utevka VI cemeteries separately from the others (Fig. 11.8). Samples from nearly as many objects were examined from Potapovka I (N = 29) as from Utevka VI (N = 30), but there is a notable contrast in the frequency of WP 2 and WP 3 in the samples from these sites that almost amounts to a reversal in pattern for the two sets. As Figure 11.8 shows, the greatest number of samples for Potapovka I exhibit WP 2 (N = 18), whereas there are almost the same number for WP 3 from Utevka VI (N = 19). In contrast, there are only half as many samples exhibiting WP 3 as there are WP 2 from Potapovka I (N = 9). The situation for Utevka VI is reversed, with only 10 samples that show

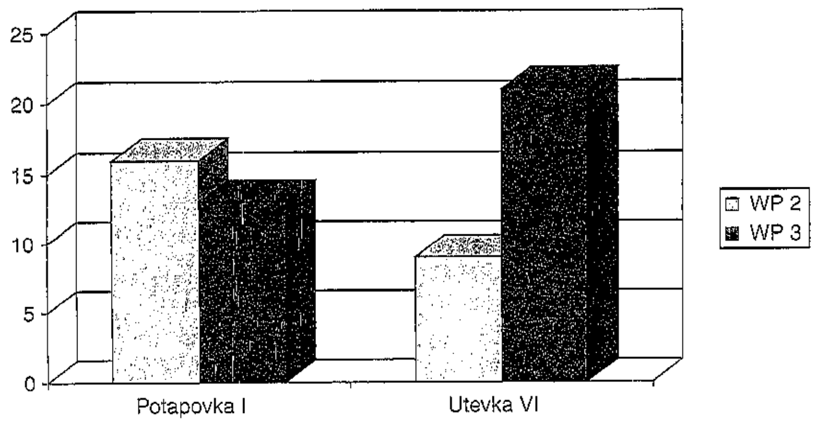

Figure 11.8. Potapovka horizon: comparison of frequency of work patterns (WP) in the metalwork from the Potapovka I and Utevka VI cemeteries.

WP 2, or approximately half the number for WP 3. These differences in degree of final cold working, and the reversal in pattern, correspond to the contrasting pattern discussed earlier in the EPMA-WDS values for iron and antimony in the samples from these sites (Fig. 11.6b). What initially seemed to be important differences in networks for the acquisition of materials also appear to relate to more fundamental distinctions in metalworking practices. This adds support to my argument that the metalwork from these cemeteries was made by different groups of workers. There appears to have been a greater tendency toward moderately cold-worked copper objects in the assemblage from Potapovka I and for heavily cold-worked arsenic bronzes at Utevka VI. For the assemblages from both sites, the majority of samples was of implements (tools, weapons) rather than ornaments (rings, bracelets, pendants, and sheet ornaments), but the group from Utevka VI contains the greatest number of copper and arsenic bronze implements exhibiting WP 3 as opposed to WP 2. The forms in these two groups are very similar, and the differences in metalworking were not related to functional differences in the objects from the two sites. Arsenic bronze is more prevalent in the metalwork from Utevka VI, which would have been more malleable and therefore more easily worked than copper. The nearest well-known source of arsenic bronze utilized in the Bronze Age is Tashkazgan, in the southern Urals region of Kazakhstan (Chernykh 1970, 1992). Any distinctions that the owners made between objects fabricated with arsenic

bronze and those with copper may have further related to the networks that were needed to acquire the former, which was less readily available than the latter.[12]

The remaining samples date to the MBA II (Grachevka II) and LBA I periods (Spiridonovka II). Of the former, the tin bronze knife with WP 1 was already described. The other four samples examined from Grachevka are also from knives. Three are copper and one is arsenic bronze. One copper knife was fabricated with WP 3, while the other three samples exhibit WP 2. The group of samples from Spiridonovka II is composed of ornaments, with the exception of one copper needle. The majority was worked by WP 2.

Discussion and Conclusions

What is the relationship of metalwork and associated practices in the Middle Volga to broader social developments, not only in the area of Samara but in the greater social landscape of the Volga-Ural? The social standing of some individuals in the Middle Volga at the end of the Middle Bronze Age, and their elevated position in relation to a wider society, has been calculated in terms of the efforts made in constructing kurgan burials, grave goods, and the animals consumed in funeral feasts and sacrifices (Vasil'ev et al. 1992, 1994). Much the same might be said of the findings for the Sintashta excavations, which appeared in print just as the research on Potapovka I and Utevka VI was completed and being prepared for publication (Gening et al. 1992). Mortuary rites, including feasting, sacrifice, and burial assemblages, are all potentially important indices of social identity and complexity. However, "social complexity" and "complex society" are labels usually reserved for situations of urbanization or early state formation. Scholars of the Bronze Age in the steppes have been largely left to consider the relatively modest remains of so-called middle-range societies of tribes and chiefdoms (Shennan 1999b), which lack the institutional framework of early cities and states. With the general rejection of neo-evolutionism, they also have lost their former relevance as a universal stage in state formation (Carneiro 1981; Kirch 1984; McGuire 1983; Bawden 1989; Earle 1991, 1997; Shennan 1993; Yoffee 1993; Wright 1994; Smith 2003: 95–96). This is perhaps no more true than in the prehistoric steppes, where there were cyclical alternations between more and less complex social forms, and in which the nature of local complexity was variable and changing (Koryakova 1996, 2002; see Frachetti, Chapter 3 in this volume). In fact, some have gone so far as to suggest that Eurasian steppe pastoralists are better approached in terms of social "stagnation" than evolution (Gellner 1994: x). This is problematic in judging developments in the steppes according to the standards established for other regions.

With the Sintashta-Arkaim phenomenon, archaeologists working in the Eurasian steppe have encountered a more nuanced form of complexity beginning in the MBA II period. The site evidence for Sintashta-Arkaim includes not only burials (Gening et al. 1992; D.G. Zdanovich 2002; Epimakhov 2005) but also settlements, which, if not proto-urban, still exhibit a new degree of centralization relative to other Bronze Age steppe horizons and the institutionalization of planned, permanent settlement for relatively large groups (G.B. Zdanovich and Zdanovich 2002). Although their appearance has been linked to pressures associated with climatic deterioration, they appear to have been accompanied by social problems with social foundations: new attitudes of hostility relative to the earlier Bronze Age, and more pronounced cultural differences and an increasing sense of social distance between neighboring groups. These changes in the social landscape of the prehistoric steppes in the MBA II period (Koryakova 2002) were accompanied by changes in the scale of the production of metal. The establishment of Sintashta-Arkaim settlements, which heralded the beginning of a new era of permanent habitations and sedentism in the Volga-Ural, accompanied the appearance of intensified metal production in the southern Urals. This was not a blanket condition of communities in the region. At many sites, the evidence indicates that output remained relatively modest (see Hanks, Chapter 9 in this volume). In this volume (Chapter 4), Anthony details the chronology of potentially inter-related developments that led up to the heightened militarism of the MBA II period and walled, fortress-like construction at some Sintashta-Arkaim settlements. Another feature may have been the initiation of the production of copper for exchange with the contemporary Bactria-Margiana oasis settlements in Central Asia.

In the absence of early state formation or unambiguous indications of urbanization, aside from burial sociology, evidence for inter-regional interactions seems to be one of the most promising avenues for augmenting current knowledge of emerging complexity in the Volga-Ural (including contacts to the south and north beyond the steppe or forest-steppe zones). The evidence presented here indicates that, during the MBA II in the Middle Volga, not only the placement of metal in burials but also the practice of metalworking itself were socio-culturally significant activities important to establishing authority at a local level. It has long been recognized that copper from the southern Urals region contributed to consumption in surrounding regions, especially to the west, including the area of present-day Samara (or Kuibyshev, as it was known in the Soviet era) (Chernykh 1970, 1992; Agapov and Kuz'minykh, 1994). This might have placed leaders in the Middle Volga in a very tenuous position. Given the lack of the indices of complexity associated with the Sintashta-Arkaim settlements, one might assume that the MBA II inhabitants of the Middle Volga were junior partners in relation to their counterparts in the southern Urals. Although many copper sources are not easily distinguished from each other by trace elements (Chernykh 1970: 37–38; 1992: 19), Tashkazgan has been established as one of the primary sources of early arsenic bronze imported to the Samara area (Agapov and Kuz'minykh 1994: 171–172) and elsewhere in the Eurasian steppe (Chernykh 1970). According to the results of Agapov and Kuz'minykh (1994: 171–172), however, the apparent shift in networks for the acquisition of metal to the Volga-Kama that occurred by the LBA I period (especially bronze) was already underway by MBA II. Even for arsenic bronze, the degree of dependence of Middle Volga pastoralists on Tashkazgan or other eastern sources is far from certain.

While my main concern here has been with developments in the Middle Volga, it is no less important to scrutinize the evidence for metal-making practices in other regions before their relationship to broader social developments can be fully appreciated. I have been very general in my treatment of the MBA II social landscape in the southern Urals, if only to point out the latitude for heterarchical relations that existed in dealings with communities in the Middle Volga, even if metal production at a substantial scale had become a significant source of wealth and power to the east (Vinogradov 2003; D.G. Zdanovich 2002). Judging from the evidence from many Sintashta sites such as Ol'gino and Stepnoye, this is far from certain. In many instances, smaller-scale activities may have been as important as they were in the Samara area (see Hanks, Chapter 9 in this volume).

Despite the incorporation of metal that originated from other regions, recycling and the maintenance of local metal pools by metalworkers in the Middle Volga created a certain degree of autonomy in their access to materials, as opposed to blanket dependence on distant sources. What could not be replenished easily through local production was bronze, which became diluted in local metal pools through recycling. While this was acquired through networks centered on Tashkazgan, it was also available from sources in the Volga-Kama as well. If partners in the southern Urals sought to impose conditions on the access to bronze and copper that were disagreeable to their counterparts in the Middle Volga, the latter could turn to other partners to the north. Therefore, the increase in social complexity in the southern Urals region at the end of the Middle Bronze Age cannot be attributed to merely an "organic" dependence of metalworking regions on mining centers. It instead involved the purposeful re-orientation of society in the southern Urals and the development of a new regime of value that may have included the commoditization of metal, production for exchange with new partners in Central Asia, and a stronger association of the value of metalwork with the material itself, rather than the skills and knowledge of metalworkers.[13] The evidence for the lengths taken to maintain local metal pools in the Middle Volga could be a sign of resistance to such changes in communities at the eastern end of the Volga-Ural. The renewed emphasis on metalworking associated with the contemporary Seima-Turbino phenomenon (Chernykh 1992; Chernykh and Kuz'minykh 1987) may further represent an invigoration of traditional modes of interaction and envaluation of metal, which incorporated public ceremony, sacrifice, and exchange of elaborate and finely crafted pieces of metalwork, rather than a more "disembedded" trade in materials. The latter, coupled with an increased scale of production, was only one possible means of establishing authority, social prominence, and/or dominance through control of the production and consumption of metal. The detailed investigation of metal-making practices in the Middle Volga shows the importance of metalworking to achieving such ends locally in the MBA II, even under circumstances of small-scale production. Similar research may eventually reveal that the same was true of many communities in the southern Urals and other regions.

Acknowledgments

I wish to thank the organizers of the Eurasian Steppe Symposium at the University of Pittsburgh, faculty and students alike, especially Bryan Hanks and Katheryn Linduff, for their invitation to participate, and their thoughtful comments and efforts in relation to this contribution. The final version benefited greatly from my interactions with the symposium's participants, particularly those whose contributions I have cited, and from the comments of two anonymous reviewers. I am also grateful to the many individuals and institutions that provided

assistance and support for the research presented here, as part of my doctoral dissertation in anthropology at the University of Chicago. Funding was generously provided through a grant from the Wenner-Gren Foundation for Anthropological Research. This material is based on work supported by the National Science Foundation under grant no. 0431940. In addition to co-directing the survey portion of the research with me, my good colleagues Pavel F. Kuznetsov and Oleg D. Mochalov (Institute for the History and Archaeology of the Volga, and Samara State Pedagogical University) made metal artifacts from Samara available for me to sample. I carried out the EPMA-WDS analysis and hardness testing at the Department of Materials, University of Oxford, with the principal assistance of Peter Northover and Chris Salter. Any errors are, of course, my own.

Notes

1. The ingots are unconsolidated in the sense that they appear unworked and "fresh" from the furnace or crucible (Vasil'ev et al. 1994: fig. 30.11), unlike the bun- or lozenge-shaped ingots noted earlier from Arkaim and elsewhere.
2. The results of the survey are discussed only briefly in this chapter, but are already available in Russian and English (Kuznetsov et al. 2005; Peterson et al. 2006; also Peterson 2007: chap. 6).
3. Comparative samples of Early Bronze Age metalwork from Velikent, Daghestan (northeastern Caucasus) were also included (Peterson 2007: chaps. 5, 7, and 8). Regrettably, these had to be omitted here because of limits of space. I am grateful to the directors of the Daghestan-American Velikent Expedition, Philip Kohl (Wellesley College), and Rabadan G. Magomedov and the late Magomed G. Gadzhiev (Institute of Archaeology and Ethnography, Makhachkala, Daghestan), for their generous efforts in providing these samples.
4. Despite new applications, researchers are now generally skeptical of trace element analysis of sources, because of the alterations that concentrations of elements undergo in the reduction of metal from ore, variations in element concentrations within the same ore deposits, and the alterations that result from alloying and recycling, which often mixed together metal that originated from different sources. In the recent study of a second-millennium BCE copper ingot and pin from Kargaly, Chernykh et al. (2006) show that relatively high concentrations of sulfur, which have been traditionally associated with primary sulfide ore deposits, can still occur in metal derived from the secondary weathered zones located closest to the surface, which were often favored by ancient miners and metallurgists. Sulfur levels no longer appear to be a secure means of distinguishing between metal produced from these respective types of ore. Nonetheless, the patterns found in element profiles still require an explanation. I have attempted to provide one here in relation to practices that surrounded metalworking, especially recycling.

In recent years, the ambiguities associated with trace element analysis have led researchers to favor stable lead isotope ratio analysis (LIA) as an alternative method of identifying sources of ancient copper, whether unalloyed or in bronze. Trace element patterns now have something new to contribute, as neutron activation analysis is currently being used to resolve ambiguities in the results of LIA in Armenia and elsewhere (e.g., Meliksetian et al. 2007).

5. Also analyzed were 11 comparative samples of Early Bronze Age metalwork from Velikent, Dagestan (see note 3). Samples from an additional seven bracelets from Samara had to be excluded after initial analyses found them to be too corroded to provide reliable results.
6. Although limits of space prevent showing it here, like arsenic, the distribution in iron concentrations in the samples as a whole also appears to relate to recycling (Peterson 2007: fig. 7.79).
7. More than 30 wt% tin was detected in one example. This high level of tin is probably owed to the heavy corrosion of the object. It therefore has been omitted from Fig. 6a and the discussion.
8. Because of limitations of space, this figure could not be reproduced here.
9. Spectral-chemical analysis of the majority of objects examined from the Potapovka I cemetery (but not Utevka VI) was performed previously by Agapov and Kuz'minykh (1994). Their results are largely in agreement with those of the WDS. However, the present research was the first in which metallography and hardness testing had been conducted on metalwork from Potapovka I and the first time that any archaeometallurgical analysis was performed for the other objects, including those from Utevka VI and Grachevka II.
10. This is the result of incomplete crystallization caused by annealing at a temperature too low for full re-crystallization, and/or for a duration too short to complete the process (P. Northover personal communication).
11. Annealing temperatures used with copper and bronze in antiquity typically ranged from 500 to 800° C (Scott 1991: 7). While bronze has a lower melting point than copper, alloy levels of arsenic or tin lower the conductivity of copper, raising the temperature at which re-crystallization may occur within one hour of heating. For copper, that temperature is 200° C, while it is 375° C for Cu + 4% As, and 450–500° C for Cu + 10% Sn. Samples with residual coring may have been annealed at a high-enough temperature for a duration sufficient for re-crystallization but not sufficient to erase all traces of the as-cast structure.
12. The Tashkazgan ores are relatively high in arsenic, so that this arsenic bronze would have been the product of smelting rather than the addition of arsenic to the copper (Chernykh 1970; 1992: 18).
13. This is a rather different notion of regime of value than the original (Appadurai 1986), in that I am insisting that a greater role was played by producers, while Appadurai (1986: 57) was more strictly concerned with circulation and consumption. One could argue that a profitable way of approaching emerging social complexity in Eurasia is in terms of changes in regimes of value, including the involvement of producers, and new understandings of the importance of people, groups, and activities, but that is a topic for another time.

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CHAPTER 12

Early Metallurgy and Socio-Cultural Complexity

Archaeological Discoveries in Northwest China

Jianjun Mei

The origin of the use of metals and alloys in China is among the central issues in current studies of the emergence of early civilizations in China. Over the past 50 years, considerable scholarly interest has focused on a debate over whether metallurgy was introduced into China or invented independently (Loehr 1949, 1956; Barnard 1961, 1983; Barnard and Sato 1975: 1–75; Ho 1975: 177–221; Smith 1977; Sun and Han 1981; Jettmar 1981; Watson 1985: 335; Muhly 1988; Wagner 1993: 28–33; Linduff et al. 2000). Most of the studies have focused on typological and technological issues concerning early metals, with only a few paying attention to the role that the use of metals and the development of metallurgy played in the emergence of complex societies in China (Linduff 1998, 2002, 2004; Shelach 2001).

Currently, our understanding of the relationship between metallurgy and socio-cultural complexity in early China is poor, and many significant questions remain to be addressed. Recent archaeological discoveries in the western regions of Xinjiang, Gansu, and Qinghai in present-day northwest China have thrown new light on the beginnings of the use of metals and alloys in that region (Sun and Han 1997; Mei 2000, 2001, 2003a, 2003b; Li and Shui 2000; Qian et al. 2001; Li 2003, 2005). On the basis of this new archaeological evidence, this chapter offers some preliminary observations on the relationship between early metallurgy and socio-cultural complexity in northwest China. I first present an overview of the studies on the beginnings and early development of copper and bronze metallurgy in the region, with an emphasis on early contacts between this area and the Eurasian steppe. Then, I propose some social